DATA COLLECTION FOR SYSTEMS OF PRODUCTION SIMULATION

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ABSTRACT

Despite the usefulness of computer simulation in manufacturing, its prevalence in the area of production preparation and management is still limited. The main reason for this situation is the difficulty with automatic data collection. In the paper the proposal of methodology for the analysis of data accessible in the information systems of an enterprise and required for the purposes of simulation model building is presented. Conclusions from an analysis of a vehicle manufacturer using the presented methodology are also described. For simulation of the production process, the usefulness of data which can be obtained from digital sources seems to be much greater if the information systems for production resource planning are, at least, MRP II class systems.
The function of the methodology was successful in the case discussed, but a more detailed practical verification based on a more intricate analysis is required. Results of the study confirm the necessity for commercial enterprises, as well as academic institutions, to be involved in the search for solutions in the area of automatic data collection for simulation purposes.

INTRODUCTION

In many commercial and academic enterprises computer simulation is now one of the fundamental research or training tools. However, in some areas, such as manufacturing, computer simulation is not yet particularly prevalent, although it is becoming more and more widely used. In the area of manufacturing, computer simulation is mostly applied by designers, constructors and technologists, while its potential is much less frequently used to optimize the processes of production preparation and management.

Such a situation is exacerbated by the lack of suitably educated and experienced analysts, as well as the fact that the tools for the simulation of the production processes are separate applications which are not embedded in the systems of production planning and control (PPC). The process of manual data collection, and the input of the data into the database of the simulation tool, in order to build a model, is very laborious and time-consuming. It is the basic obstacle to the conducting of simulation projects. This obstacle has two dimensions: economical (time, costs); and psychological (a long wait for results, which may not live up to expectation).

Experienced simulation analysts use models built during one project for working on another. In a survey, conducted by Robertson and Perere during the Winter Simulation Conference in 1999, it was found that 27% of respondents reuse previously built models for a different purpose, while 42% keep the model updated. The poll also revealed that:

- 60% of respondents manually input the data to the model,
- some companies rely 100% on the manual method, whereas others rely 100% on a link to an external system (Robertson and Perere 2001).

The research of Robertson and Perere, observations of realities in which production companies are operating, and demands from industry, as well as the academic environment, indicates the need for an automatic data collection method for simulation models and such automatic data collection could substantially contribute to an increase in the use of simulation in production management. The basic electronically stored data sources which can be used for building production process simulation models are PPC systems (or production planning and control modules of integrated systems).

The awareness of the importance of the integration of Enterprise Resource Planning (ERP) systems with external applications is increasing among producers and efforts are being made to find solutions.

For data which is necessary for the modelling of the production process and which can be exported from a PPC system, the technological process and the current or planned machine capacity must first be dealt with. The automatic exchange, vis-à-vis the integration of simulators with information systems for production management, is a difficult problem which requires a detailed analysis of the data structures, an investigation of the technical alternatives for their exchange and a one by one programming of an interface for each different variation.

This paper presents a methodology for the analysis of data accessible in the information systems of an enterprise and required for the purposes of building a production simulation model. Conclusions from an analysis of a vehicle manufacturer using the presented methodology are also described.

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METHODOLOGY FOR THE ANALYSIS OF DATA REQUIRED FOR PURPOSES OF SIMULATION

As mentioned, a step by step process of data collection during the building of a simulation model is very laborious and time-consuming and therefore a decision in an enterprise to look for a digital data source is economically justified. The work invested in the identification of such data sources and an assessment of their adequacy, in the majority of cases, pays off and seldom leads to the conclusion that manual data collection is necessary because of an absence of suitable digital data sources. However, even where such a search is not successful, to judge the time spent on the identification and analysis of potential digital data sources as lost time is, at the least, debatable. An analytically proven absence of digital data sources for simulation purposes can be judged as essential knowledge for model building.

An algorithm of an analysis of potential data sources for the simulation of production processes will be presented below. It can be applied in simulation projects relating to the design of production systems as well as in projects relating to the management of production systems on the operational level.

Assumptions

The model builder and/or project team will have performed the following activities before they start the analysis of digital data sources:

a) they will have established the assumptions relating to model building (simulation aim, limits of modelling system, level of details in the model),
b) they will have specified what data is required to build the model,
c) they will have identified the key data sources (e.g. paper documents, knowledge of employees, observations of real system's behaviour, digital sources).

After the assumptions for the simulation project have been established, the analysis of the potential data sources can begin. The first step will be an analysis of whether the information systems supporting the production management mirror the processes involved in simulation research, and, if so, to what extent. This will be followed by an investigation of the nature of the data stored and processed by the analyzed systems and responsible for describing selected processes or sub-processes. If we are dealing with the application of simulation in the area of *System Management* it is also necessary to investigate the frequency of data modification in comparison to the level of details in the simulation model. The next step is a detailed analysis of the identified data, which will include structure, type, optionality, completeness and redundancy. For each step the results obtained form the input data for the following step. Finally, an auxiliary database can be created where metadata i.e. data about data (Gramacki and Darulewski 2001) is stored. This tool is useful for the storing, in a structured form, of the results of the detailed analysis of the data which is accessible in the information systems of an enterprise and which is necessary to build a simulation model. Information relating to the necessary modifications and additions to the data can also be stored in such a database.

Each of the described analytical steps increases the accuracy of the knowledge of an analyst or project team relating to such issues as the required data and to what extent this data can be automatically collected. The analytical algorithm is explained in more detail in figure no. 1 (next page).

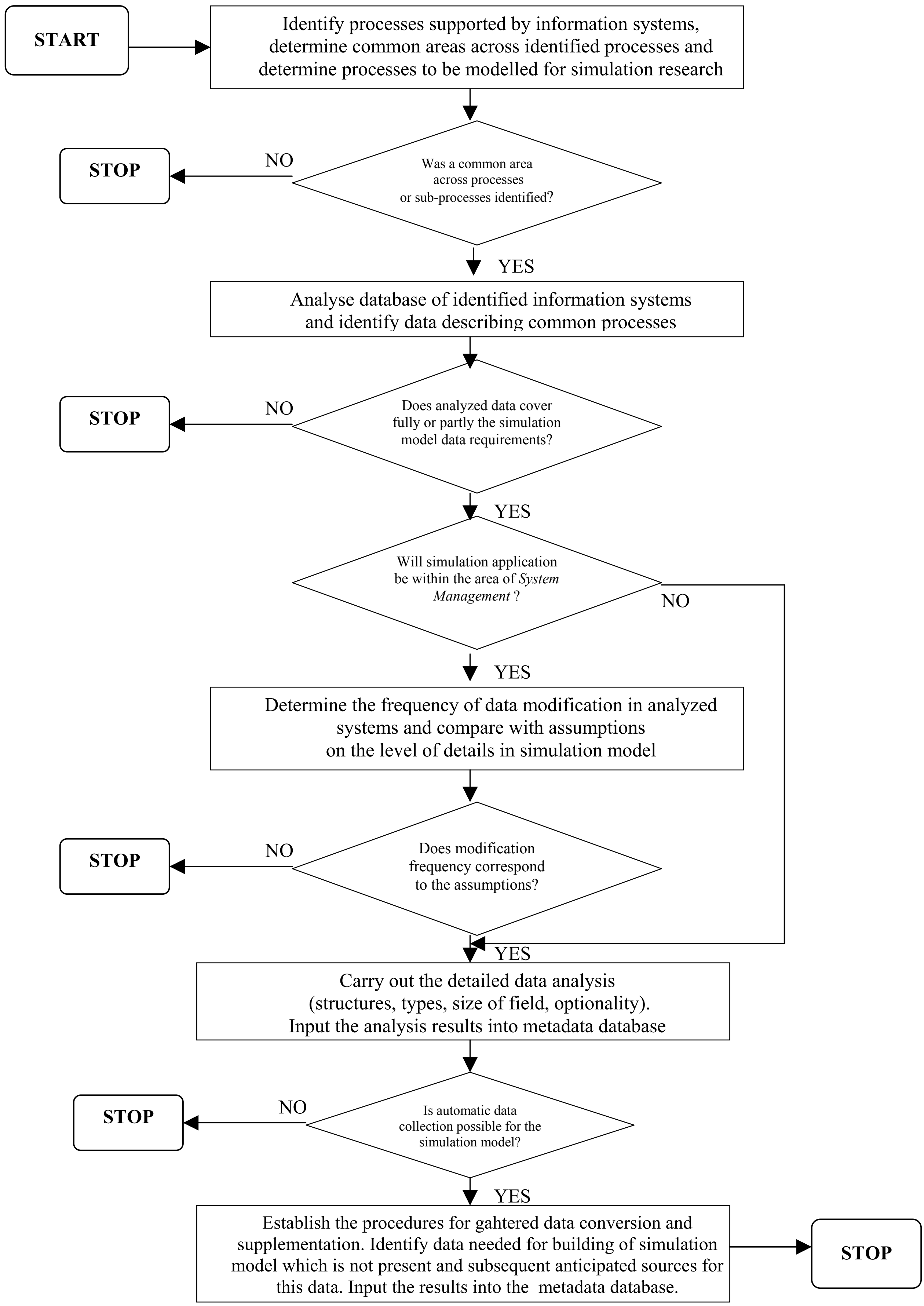
The end result of the method is a database containing metadata, which supplies us with information on what data can be collected automatically and what data must be entered manually into the model. The database also contains information on the procedures which must be executed in order to convert or complete data, or to remove redundant data.

DATA ANALYSIS FOR SIMULATION PURPOSE – CASE STUDY

Data Analysis

The methodology as presented above, excluding the setting-up of a metadata database, was applied to a vehicle manufacturer for the analysis of data accessible in the production management information systems.

In this enterprise, because of the uniqueness of the production process, the manufacturing process is not automated and technological operations are conducted manually. This is a classic example of unit production to customer order. The end product is one of the possible variants of an earlier defined vehicle model, which fulfils customer requirements for construction and technology. The complexity of the production process, and subsequently the complexity of the production management, means that the enterprise is seeking new tools for production planning and its optimization, and intensive work is being carried out to apply discrete event simulation. At the moment, the company uses some systems of production planning and control which can form the potential data source for the building of the simulation model. As the result of the first analytical step at the process level two information systems emerged for further analysis.



Figures 1: The Algorithm of Analysis of PPC Systems Data for Simulation Purposes

System no. I is on the Ms Access® database based tool, which is used for the archiving of vehicles' production plans as well as for the generation of new plans on the basis of historical data. The system is used for operations which include estimating the time for the production process based on the times of the singular technological operations needed to perform the planning of manufacturing resources which are involved during the production process. System no. II is the company dedicated, multiaccessible software for production planning and control which works in the client-server architecture via the Internet. The system is used for the management of manufacturing plans, the estimation of production costs and the planning of material requirements. The system database contains detailed data on customer orders and production plans including times for the release of production orders.

The data analysis for the two systems was worked out by utilising the re-engineering concept. The results of the data organisation analysis were documented with entity-relationship diagrams, which usually document the first step of the database design process, the analysis of the so called "miniworld" (figures 2 and 3).

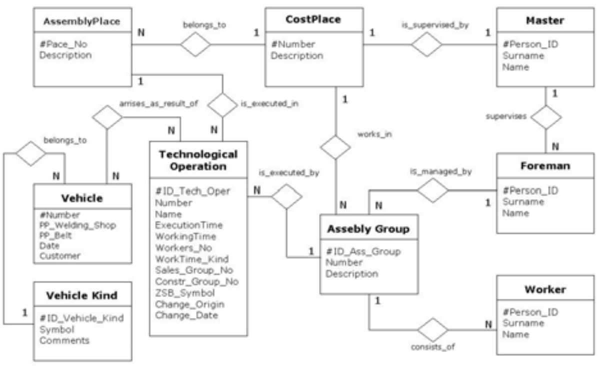


Figure 2: Entity-relationship Diagram
from the Ist System

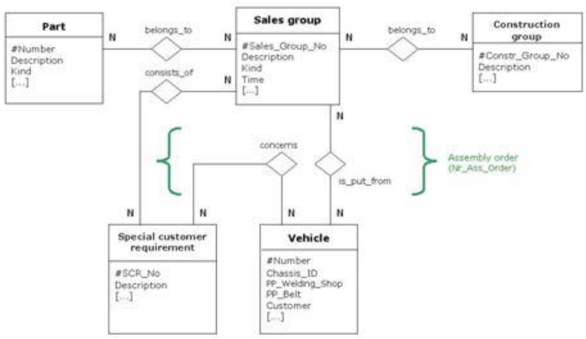


Figure 3: Entity-relationship Diagram
from the IInd System

The rough data analysis of both systems revealed that the production process is perceived from a different point of view by each of the two systems. The logic of the data in system no. I reveals features of the process approach. Production data is interpreted by the system through the prism of technological operations, which are treated as the basic unit of production planning, and the production process is modelled as the sequence of these operations (the entity *Technological Operation* as shown in figure 2). Conversely, the logic of the data in system no. II primarily takes into consideration the construction of the vehicle, and the production process is modelled by means of the view of the end product amalgamation of the objects which represent construction components such as the engine, the driveshaft, or the air-conditioning (the entity *Sales Group* as shown in figure 3).

Time, which is the key parameter in the modelling of the production process, is an attribute of the *Technological Operation* entity in the first system, whilst, in the second system, time is an attribute of the *Sales Group.* The linking of the time parameter to the *Sales Group* was based on intuition and estimation, whereas the linking of the time parameter to the *Technological Operation* was the result of executed mensuration. The data relating to time and resident in system no. II is unhelpful to the modelling of the production process because the image of the final end product amalgamation of the construction objects does not correspond to the reality of the production process in which components of one *Sales Group* are assembled into the vehicle in assembly process stages which are not always sequential.

Data which is stored and processed by the first system describes many of the production process parameters which are essential from the simulation's point of view. However, they are not complete and need to be converted and completed.

Simulations as Verification of Data Collected from Digital Sources

On the basis of data identified in the database of system no. I, the simple models of the production sub-processes were built and used to verify the data. The behaviour of the model was compared with the observation of the real system.

The constructed models mirrored the painting processes (Skrzypczak 2004) and the finishing process (Wesołowski 2004) in the vehicle factory. Because of the highly diverse forms of organization in both cases, different modelling and simulation tools were used. In the case of the paint shop where there were not a large number of variants in the production process, and where the random factor had a small influence, the simulation model was built using a spreadsheet. In the area of finishing, where there was a high level of dynamism and a large number of possible process variations, as well as the large influence of disruptions from the earlier stages of the manufacturing process, and a large random factor, in order to model the production system behaviour, the discrete event simulator Arena® was applied.

The diagrams below illustrate example models for data verification (figures 4 and 5).

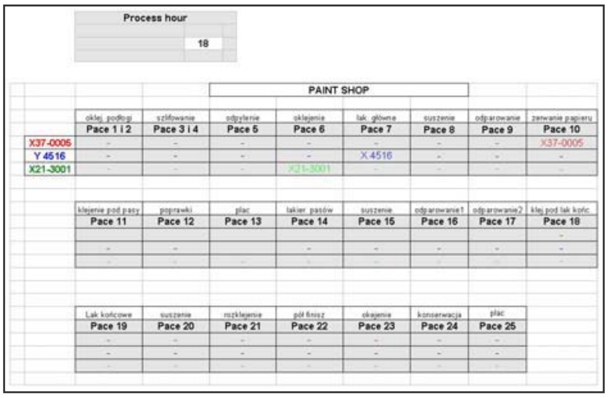


Figure 4: Model of Painting Process
for some Types of Vehicle

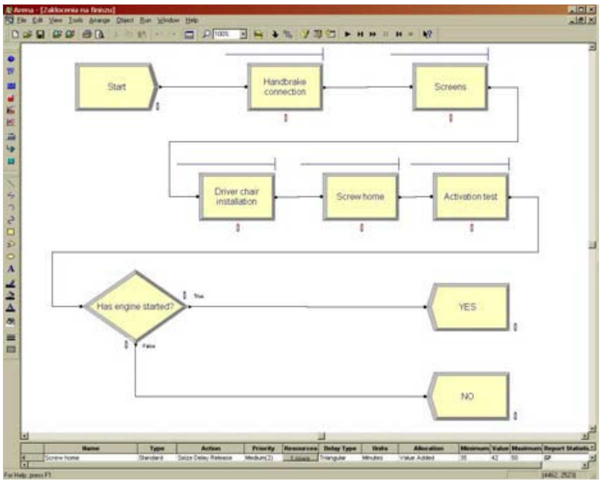


Figure 5: Model of the Finishing Sub-process
in the Vehicle Factory

The results obtained reflect the conclusions drawn on the basis of real system observation, which confirms the adequacy and correctness of the data used for simulation.

In the case as discussed, the data analysis resulted in the conclusion that only a fraction of the data, after conversion and supplement, can be used to build a simulation model. In the opinion of the authors, the reason for this is the fact that the PPC systems as used by the vehicle company do not meet the MRP II standard. Although generally accepted standards for data structures do not exist for MRP II/ERP systems (Robertson and Perera 2001), the algorithms of material requirements and manufacturing resource planning require certain data to be present in the database, data that was absent in this case. It can be concluded that the usefulness of data analysis which can be obtained from digital sources, and which can be used for the simulation of the production process, seems to be much greater if the information systems for production resource planning are, at the least, MRP II class systems.

Because of the uniqueness and complexity of the production process in the company concerned, as well as the large frequency of change in the input parameters for simulation, the enterprise has made the decision to produce a dedicated simulator using a high level programming language. The data analysis carried out contributed to this decision and delivered the relevant information on the range of data existing in digital form for simulation purposes, as well as its degree of usefulness.

SUMMARY

The presented methodology for the analysis of the data which exists in the database of PPC systems, and which is required for the purposes of simulation, is a proposal only. However, in the case discussed, the function of the methodology was successful.
But saying this, a more detailed practical verification based on a more intricate analysis, is required.
The authors of the paper must draw attention to the necessity for commercial enterprises, as well as academic institutions, to be involved in the search for solutions in the area of automatic data collection for simulation purposes. A mutual cooperation in this area between PPC (MRP II/ERP) systems, simulation software vendors and universities could offer many rewards.

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